WALLIAN (S.S.)

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Synonyms: Peroxide of hydrogen; binoxide of hydrogen; deutoxide of hydrogen; oxygenated water. French: L'eau oxygéné; hydrogène dioxyde. German: Wasserstoff-superoxyd. Symbol, H_2O_2. Specific gravity, 1·453.

Without stopping to consider its ultimate relations and reactions, it would seem to be a misapprehension or a physical inconsistency to classify this compound with aeriform bodies, since it is usually recognized and dealt with as a liquid only, notwithstanding the fact that it occurs and is constantly produced in minute quantities by natural processes in the form of impalpable vapor. But when it is remembered that it has little or no value or effect, either as a prophylactic, therapeutic, or chemic agent, until by chemical decomposition it yields one equivalent of its oxygen in a free, gaseous, and intensely active condition, the apparent inconsistency disappears.

First definitely identified by Thenard in 1818, this product of the laboratory—which, however, as already intimated, is also constantly evolved by strictly natural causes in certain localities—is quite unique, resembling nothing else in nature, and being unlike any other product of the chemist's

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art. In its physical characteristics and vital reactions the only substance or element which it resembles is ozone, and in its ordinary physical condition it is quite unlike this peculiar agent.

In its pure and undiluted state it is of a syrupy consistence, has a specific gravity nearly one half greater than that of water, and is of such an extremely unstable nature that it decomposes on the slightest provocation, such as slight change of temperature, agitation, or metallic contact, and sometimes this change occurs with explosive violence. On decomposition it yields free and active oxygen and simple water.

The variety of names used to designate this product is decidedly confusing to beginners, and it is to be hoped that a uniform nomenclature will soon be recognized and adhered to. Chemists formerly called bioxide of hydrogen, or oxygenated water; ordinary water, under the same system of nomenclature, being protoxide of hydrogen. The name peroxide, by which it is now generally and popularly known, is one of those persistent inaccuracies and inconsistencies with which modern scientific and pseudo-scientific literature is still, to some extent, encumbered. The term peroxide should never have been introduced into chemical literature at all, since of itself it does not indicate any definite degree of oxidation. It is presumed to describe the highest possible degree of oxidation, in case of the particular element under consideration, and may therefore indicate in one case a dioxide, in another a teroxide, tetroxide, or possibly a pentoxide, according to the degree of oxidation to which any particular substance or element can be carried.

The highest known oxide of hydrogen is the dioxide or binoxide. It was therefore, in accordance with the prevailing practice, called the peroxide, and, as already stated, is better known by this unscientific and inaccurate name than

by its proper chemical title, hydrogen dioxide. Under the old system of nomenclature, the modern changes in which are confusing to those who conned their chemistry lessons a quarter of a century ago, water was represented by the symbol HO, and the compound under consideration by HO_2. The present system writes H_2O for common water, and H_2O_2 for hydrogen dioxide.

As regards physiological effects and some of its chemical reactions, hydrogen dioxide is so closely allied to ozone that it has been plausibly maintained that one is merely a liquid and possibly allotropic condition of the other. The two substances similarly affect both the iodide of starch and thallium test-papers. The seeming contrast in the physical conditions, one being recognized as uniformly a liquid and the other as a gaseous body, may in reality be more apparent than real, since ozone, according to Mulvany, prevails only in moist atmospheres, and may therefore plausibly be presumed to exist in the form of suspended and impalpable vapor, or, next to that, as hyperactive (condensed) oxygen at the instant of its evolution through the decomposition of hydrogen dioxide, which latter is undoubtedly always present to some extent in the form of vapor in all moist atmospheres. In fact, it is not a scientific exaggeration to assert that the atmosphere itself is at all times but a vast aerial ocean (Ewing), varying from time to time in the degree of its aqueous permeation or paucity, as the case may be—a condition usually referred to as that of relative humidity.

Recent medical writers, in their casual references to hydrogen dioxide, are quite inclined to carelessness of statement, especially as to volumetric strength. Thus one writer, himself the associate author of a recent work on materia medica, which makes his blunder wholly inexcusable, advises its use "of full strength," which means anything or nothing, according to the understanding or preconceptions of

the reader. It is to be presumed that he intended to say it might be used of the full strength of whatever solution he had been in the habit of receiving from his pharmacist; which, judging by samples obtainable in the market, might vary all the way from five to fifteen volumes, according to the brand selected, or according to its age. Too many reporters on the use of this agent also disclose the unmistakably commercial bias of their inspiration by over-enthusiastic mention of some particular preparation, after the generally transparent manner of proprietary puff-writers. In fact, modern medical literature is getting to be very liberally padded with this sort of semi-quackery. In the face of the existing confusion a word as to volumetric strength will not be out of place.

Pure and undiluted hydrogen dioxide, on being entirely decomposed, is found to yield four hundred and seventy-five times its own volume of oxygen, leaving behind one volume, or nearly one volume, of water. In this state it can be handled or retained only by being excluded from light and kept below freezing point; hence a so-called "pure," undiluted, or "full-strength" preparation of this product is unknown in the market. Nor is it ever chemically or therapeutically desirable, since in this concentrated form it can not be used for any practical purpose whatever. For pharmaceutical purposes a fifteen-volume (about three per cent.) solution is as strong as is either desirable or available. Very little of that in market will test above ten or twelve volumes, and much of it is as low as four or six. In fact, some manufacturers do not attempt to supply a solution exceeding ten volumes (about two per cent.) in strength. For a majority of therapeutic uses even this strength requires further dilution. Richardson suggests that a ten-volume solution be made the standard.

Preparation.—To prepare absolutely pure hydrogen di-

oxide, in solution, Crismer (*Bull. de la Soc. chim.*, Paris) recommends the following:

Binoxide of barium is mixed with distilled water to the consistence of thin milk. Decomposition is induced by the addition of hydrochloric acid of the specific gravity of 1·100. By the addition of ether and agitation, a portion of the resultant dioxide of hydrogen is dissolved out. This is to be separated and shaken with pure water, to which it yields a portion of the desired product. The remaining ethereal solution is again separated and brought in contact with a fresh portion of barium solution. The whole operation is to be repeated several times, which will afford a solution containing from one half to one per cent. of perfectly neutral hydrogen dioxide, free from chlorine and all other constituents except a small quantity of ether, which is presumed to aid in imparting stability to the product, but which may be removed by distillation *in vacuo*, if for any special reason it is deemed objectionable. Prepared in this way, the product is comparatively stable, but is subject to gradual deterioration, or rather to slow decomposition.

According to Gmelin, the original theory laid down by Thenard is, that the "peroxides" of any of the alkaline minerals—barium, calcium, potassium, sodium, or strontium —may be used in producing hydrogen dioxide by being digested "in any hydrated acid which forms a soluble salt with the salifiable base resulting from the decomposition of the peroxide," since the released oxygen does not escape as gas, but unites with a portion of the water, and thus "converts it into peroxide of hydrogen."

Practically it has been found that the binoxide of barium answers the purpose best; hence this chemical is generally, if not universally, employed. The original process consists in diluting fourteen parts of pure hydrochloric acid with nine hundred and sixty parts of distilled water. Thir-

teen parts by weight of pure baryta, finely pulverized, are to be dissolved in this solution, which is to be thoroughly stirred with a glass rod or wooden ladle during the process. Chemical reaction ensues, by which the binoxide is changed into soluble chloride of barium. The barium should be first reduced to the consistence of a thin paste, all utensils employed in the entire process being of glass, glazed or enameled ware, or wood. By the above-described manipulation sufficient oxygen will have been liberated to charge the water menstruum to about one volume strength ($\frac{1}{4}\frac{1}{5}$) of hydrogen dioxide, but the product is encumbered with all the chloride of barium evolved by the process. Dilute sulphuric acid (1 to 4) is now to be slowly added and the mixture thoroughly agitated or stirred, which results in precipitating the barium in the form of an insoluble sulphate, and leaves the hydrochloric acid free. The solution is now to be decanted, a fresh portion of barium paste added, and the process repeated until the desired volume of strength has been obtained. Beyond eight or ten volumes' strength, which is sufficient for most purposes, further concentration may be accomplished by gentle evaporation.

To remove the free hydrochloric acid, sulphate of silver is slowly added, forming chloride of silver, which is precipitated, leaving free sulphuric acid in the solution. The product is now to be decanted and treated with barium until all the sulphuric acid is fixed and deposited as insoluble sulphate. Again decanting and carefully filtering, the result is an approximately pure and neutral product. Richardson asserts that the removal of the free hydrochloric acid is hardly necessary, since the relatively small percentage of it is but a slight disadvantage, therapeutically considered, and that its presence adds to the stability of the solution.

Coming from the source it does, this statement is a surprise, since it is unquestionably a chemical mistake. From

the predominance of distinctly acid solutions in the market, it is evident that some manufacturers are very glad of this eminent and well-meant but delusive indorsement of their incomplete methods.

Again, to conceal defects of manufacture and render their imperfectly purified product more perfectly transparent and brilliant in appearance, it is asserted that some unscrupulous manufacturers regularly add a certain percentage of alum, and in some cases even oxalic acid, to the dioxide solution.

Such adulterations are simply criminal, and it is no doubt due to their presence that unexpected and disastrous results have occasionally followed the clinical exhibition of this agent.

Another process of manufacture, recommended by Pelouze and called the direct method, consists in treating binoxide of barium with a solution of hydrated hydrofluoric acid. The resulting reaction includes the decomposition of the barium, the formation and precipitation of fluoride of barium, the liberated oxygen of the decomposed salt combining with a portion of the water to form dioxide of hydrogen, as in the processes already described. This process is highly esteemed for preparing the commercial article on a large scale.

Value and Uses.—Inferentially it may be safely asserted that any therapeutic agent or preparation which, in spite of the preponderance of indifferently good and even absolutely bad samples in the market, can acquire and retain the reputation now held by the product under consideration, must possess positive, inherent, and extraordinary therapeutic merit. Certainly no higher encomium or evidence of substantial value could be adduced for this unique preparation than that it has compelled almost universal professional recognition, and is now being used in almost incredi-

bly large quantities, compared with the limited demand of even five years ago. It would therefore be difficult to predict the future of this agent.

It is now extensively advertised, and one can hardly refer to the medical journals without finding enthusiastic recommendations of it as a disinfectant of rare efficiency, an antiseptic of recognized merit, and a germicide of decided potency. As a germicide, Miquel places it third on the list, only the biniodide of mercury and the iodide of silver surpassing it in this direction. It is also a reliable sporicide, and at the same time it is non-toxic and non-corrosive—qualities possessed by few if any of the other sporicides yet brought to notice.

As already intimated, its therapeutic value is wholly due to the liberation of its extra atom of oxygen, which, derived from this source, is found to be in an exceedingly active condition approximating ozone. Freed from its loose combination with the hydrogen base, this ozonized atom promptly attacks every form of germ life, decaying organic particles, pus, or foul secretion with which it is brought into close contact, effectually sterilizing or destroying it by a process of rapid and complete oxidation. Nothing could be simpler in action or more satisfactory as to results. Its decomposition leaves behind simple water only, hence there is no reaction following its use and, even in case of the most sensitive surfaces, no irritation worthy of the name; in fact, its immediate effect is that of a moderate analgesic. It as promptly allays the pain and excessive irritability so uniformly present in carbuncle, whitlow, phlegmon, and irritable ulcer, as if it were really an anodyne; and it may be used with the most lavish excess without the remotest danger of hurtful absorption or toxic after-effects.

It is evident that an agent possessing these indicated properties is susceptible of innumerable uses and applica-

tions; in short, that its range of applicability in medicine and surgery is practically unlimited. It cleanses and disinfects foul wounds and ulcers promptly and thoroughly; it is a satisfactory application to some forms of abrasions, and to abscesses and ulcers of every description. In acne, topical applications, repeated several times a day, have given excellent results. As a mouth wash it proves effective in aphthæ, and it will frequently abort herpes labialis and hordeoli if freely applied two or three times, at short intervals, during the threatening stage. It is a reliable application in all cases of stings and bites of insects, dissection wounds, and blood poisoning from any cause. Used as a spray and by inhalation, either from a nebulizer, vaporized by heat, or by means of an inhaler to be mentioned further on, it adds greatly to our resources in amygdalitis, pharyngitis, laryngitis, and bronchitis; and in diphtheria it destroys the infection and removes the membrane more certainly, speedily, and safely than any other known solvent which is at the same time a disinfectant. In hay fever and whooping cough it has been lauded by several observers of note as next thing to a specific. It is used with brilliant results in the various forms of ophthalmia, blepharitis, corneitis, conjunctivitis, etc., and does excellent service in chronic cystitis, cervical catarrh, and leucorrhœa. It is enthusiastically recommended by several writers in all stages of gonorrhœa, but is undoubtedly most valuable in the later and chronic stages. In otorrhœa and subacute and chronic otitis media it is highly extolled by Dayton and others who have experimented with it in these cases. Topically applied, mixed with pure glycerin, it arrests gangrenous suppuration and promotes healthy granulation.

Its disinfectant properties are very pronounced in all forms of eruptive fevers and infectious diseases. Freely spraying the room with a ten-volume solution will destroy all

foul odors and act as an important auxiliary to other measures. By means of a spray apparatus it may be made to supply active oxygen to the apartment, and to largely obviate the disastrous results of imperfect ventilation. If it had no other use, its value in this direction, though as yet little appreciated, is fairly incalculable.

Internally it has been resorted to by Le Blond and others in diabetes, but not with the success which was theoretically anticipated. Temporarily, it lessened the quantity of sugar, but the effect was neither uniform nor permanent. This failure has been the subject of considerable speculation, and is a marked illustration of the apparently unaccountable variation in therapeutic action manifested by the same agent or element under slightly different physical, chemical, or dynamic conditions. Thus Le Blond and his *confrères* found that although hydrogen dioxide, exhibited internally in diabetes, failed to oxidize and eliminate the saccharine element in the blood, a result which they had confidently predicted, oxygen, exhibited by other methods, especially in the form of oxygenated water—*i. e.*, distilled water charged with several times its bulk of pure oxygen, under pressure—promptly corrects the diabetic tendency, and in a large percentage of the cases causes the sugar to entirely disappear, this effect being readily maintained.

In fermentative or flatulent indigestion and in chronic gastric catarrh its internal use has been followed by decidedly favorable results, since it promptly checks yeasty and acid fermentation and cleanses the lining membrane of the stomach from the tenacious mucus which so seriously interferes with both digestion and effective medication. In catarrh of the lower bowel, and especially of the rectum, it has proved of great value. It is to be used both internally and by enema, first being reduced to a strength of

from one to five volumes (0·2 to 1 per cent.) or less. In all accessible passive hæmorrhages it has been found to act as a hæmostatic, doubtless from its action in coagulating fibrin; hence it may be tentatively administered internally in hæmatemesis, inhaled in the form of nebulized vapor in pulmonary hæmorrhage, or injected in cases of hæmaturia and hæmorrhage of the lower bowel. Spraying the post-nasal passages with a one- to two-per-cent. or stronger solution will generally check epistaxis, even of severe type. Considerable relief follows its use in gastric ulcer, and also in carcinoma of the stomach. In ozæna it is a readily available detergent and disinfectant, admirably preparing the diseased surfaces for the effective application of other remedies. In rectal and uterine cancer it is invaluable, relieving pain at the same time that it cleanses and disinfects the parts. As a source of free oxygen for use by inhalation it is available in asthma, cardiac dyspnœa, bronchitis, pertussis, phthisis, and many other conditions and emergencies. Richardson has devised a very convenient apparatus for its administration in this form, consisting of a large glass vessel, tubulated, and having a wide mouth into which a perforated cork is fitted for holding the solution of dioxide, and a second smaller vessel with an outlet tube projecting from the bottom and provided with a stop-cock. The outlet tube of the second vessel is to be inserted into the perforated cork, and this receptacle is to be partly filled with a saturated solution of permanganate of potassium. To the outlet tube of the larger vessel is attached an inhaling tube and double-valved mouth-piece. When in use the permanganate solution is allowed to trickle slowly into the dioxide solution contained in the lower vessel. The evolution of ozonized oxygen is thus immediately induced, and may be readily controlled. By means of this apparatus combinations of almost any of

the volatile medicaments may be made, such as ether, nitrite of amyl, etc., with oxygen, and the effect thereby greatly enhanced. Richardson enthusiastically recommends the combination of oxygen and ether ("ozonic ether") for producing safe anæsthesia, claiming that the necessity for removing the mouth-piece or inhaler from time to time during the operation is entirely obviated, the patient constantly receiving a sufficient supply of oxygen to prevent all danger of asphyxiation.

The same authority recommends many mixtures for internal administration, the following being representative samples of his formulæ:

(1) ℞ Sol. hydrogenii dioxid. (10 vols.)..... ℥ ijss.;
Acidi sulph. dil..... ʒ jss.;
Glycerini..... ℥ jss.;
Aquæ dest.....ad ℥ vj.
M. Sig.: Dose, one ounce, well diluted.

This he has found an excellent mixture in the colliquative sweating in phthisis.

(2) ℞ Sol. hydrogenii dioxid. (10 vols.)..... ℥ ijss.;
Quininæ bisulph..... gr. vj;
Acidi hydrochlor. dil..... ♏ xx;
Glycerini..... ℥ jss.;
Aquæ dest.....ad ℥ vj.
M. Sig.: Dose, one ounce in iced water.

(3) ℞ Sol. hydrogenii dioxid. (10 vols.) .... ℥ ijss.;
Liq. morph. hydrochlor..... ʒ j;
Syr. Tolutan..... ʒ vj;
Glycerini..... ℥ ijss.;
Aquæ dest.....ad ℥ vj.
M. Sig.: Dose, one ounce, diluted with iced water.

Excellent in asthenic bronchitis and in phthisis with severe cough and sleeplessnes.

(4) ℞ Sol. hydrogenii dioxid. (10 vols.) .... ℥ ijss.;
Syr. codeinæ..... ʒ ij;
Sp. vini rect., }
Glycerini, } .....āā ʒ vj;
Aquæ dest.....ad ℥ vj.
M. Sig.: Dose, one ounce in iced water.

A palliative of pronounced value in diabetes, giving much better results than codeine alone.

(5) ℞ Sol. hydrogenii dioxid. (10 vols.) .... ℥ ijss.;
Acidi phosphorici dil..... ʒ j;
Syr. ferri superphos..... ʒ vj;
Glycerini..... ℥ j;
Aquæ dest.....ad ℥ vj.
M. Sig.: Dose, one ounce in iced water.

Recommended in all asthenic cases in which iron, phosphates, and oxygen are indicated. Used with marked advantage in the early stages of phthisis.

Many other mixtures may be made, including strychnine, nitrite of amyl, quinine, caffeine, etc., but the foregoing are sufficiently suggestive.

Richardson highly extols the mixture referred to as "ozonic ether," which is prepared by mixing a thirty-volume, or the strongest obtainable, solution of hydrogen dioxide with anhydrous ether, and adding five per cent. of alcohol. This is to be administered in water, in doses of half a drachm to two drachms, and may be applied topically in the form of spray. In pertussis, he claims, no remedy is more effective than the following mixture:

(6) ℞ Ætheris ozonici..... ʒ iij;
Syr. Tolutan..... ʒ vj;
Glycerini..... ʒ iv;
Aquæ dest.....ad ℥ vj.
M. Sig.: Dose, one ounce in iced water.

He also uses dioxide of hydrogen as a substitute for iodides and mercurials, as follows:

(7) ℞ Sol. hydrogenii dioxid. (10 vols.) .... ℥ iijss.;
Liq. potassæ..... ♏xxx;
Glycerini..... ʒ vj;
Aquæ dest.....ad ℥ vj.

M. Sig.: Dose, one ounce in cold water, to be pushed until ptyalism is induced.

From the foregoing it will be evident that this agent can be readily adapted to very many morbid conditions in connection with which no mention of it has yet been made by any writer.

As a prophylactic it may readily be adapted to numerous and important uses. Its marked antifermentative power makes it available as a sterilizer of both water and milk. Uffelman, Paul Bert, Von Tromp, Althoefer, and others have investigated it in this direction with very gratifying results. As an outcome of their exhaustive tests, which it is unnecessary to describe, it was found that "all impurities and pathogenic microbes in surface, river, or well water can be totally removed and destroyed in twenty-four hours by using one part of hydrogen dioxide to one thousand parts of water." *

A drachm or two to the quart will effectually sterilize milk—a method which has some advantages over heat. Added to new milk, it decidedly retards lactic fermentation.

Uses in Dental Surgery.—By the use of hydrogen dioxide the dental surgeon can accomplish results of which he did not dream before its properties had been demonstrated. It will cleanse and render aseptic the foulest cavities, without irritation or injury to the adjacent tissues. Through its action as an analgesic, a sensitive pulp or cavity can be treated and filled at the same sitting, instead of requiring,

* *Ctrlbl. f. Bacteriol.*, July 10, 1890.

as heretofore, several days of preparatory treatment. It is also availed of in treating alveolar abscess, abscess of the antrum, as an injection into the pockets of pyorrhœa alveolaris or Riggs's disease, and for bleaching pulpless and discolored teeth. In the language of one of the profession, treating of dental surgery: "The introduction of H_2O_2 in our practice is revolutionizing the treatment of the foregoing diseases, as it is likely to do the various departments of ophthalmic, aural, and genito-urinary surgery." *

Practical Tests.—The instability of the article usually found in the market (and this applies to nearly all of the brands offered, as will appear from the report of samples tested given below) is a serious drawback to its more general employment, both on account of the varying and uncertain strength of different samples, or of the same sample from day to day, and on account of making it practically much more expensive than it should be. Nor are the precautions of tight corkage and cool storage, especially the former, of any avail. If decomposition is taking place, confining the released oxygen by a stoutly-wired-in cork does not materially hinder the process. Using non-actinic glass bottles as containers, and secluding from the action of strong light, are, however, valuable aids in its preservation. The question of the kind of cork to be used is of some importance. Rubber is somewhat expensive, if strictly "pure gum" is used, and I have thought this usually unexceptionable substance seems to excite more or less tendency to decomposition. Scrupulously clean, ordinary cork, of the finer or "velvet" variety, it is claimed by some, exerts the least effect on the solution. But the best of ordinary cork is quickly bleached and finally softened by the action of the solution. Ground glass stoppers are both effective and unobjectionable, except on account of cost.

* Harlan.

Hyperacidity is an equally prevalent and even more serious fault. The pure product yields a slightly or apparently acid reaction, reddening, or rather bleaching, sensitive litmus paper; but, notwithstanding Richardson's assertion to the contrary, the presence of any excessive or, in fact, of any marked free acidity whatever, renders it more or less obnoxious and irritating, whether designed for internal or external exhibition.

As insisted by those scientists who have been foremost in urging professional recognition of the claims of this agent, it should be practically neutral and almost as bland and non-irritating as pure water. Chemically speaking, one litre of a fifteen-volume solution of H_2O_2 should be completely neutralized by five or six cubic centimetres of the U. S. P. standard (ten per cent.) solution of ammonia. If it still shows reaction on blue litmus, it is conclusive evidence that the sample contains an excess of free acid. A perfect article for medicinal use leaves a somewhat unpleasant sensation in the throat, but should not impart a sense of sharpness or decided acidity to the taste. It may be described as having a faintly metallic taste, such as is experienced on touching the tongue or lips to an electrode connected with a mild galvanic circuit. A harsh, sour, or astringent sensation in the mouth indicates the presence of free acids, alum, or some other foreign ingredient.

The alkaline impurities most likely to be found in samples tested are calcium, magnesium, barium, and strontium. One or more of these earths, or some compound of them in solution, may exist in any given sample without in any way interfering with its general appearance or lessening its transparency. To detect these, first add to a small quantity of the samples, in a perfectly clean test-tube, a few drops of phosphoric acid and agitate briskly. This will insure a thorough solution of any merely suspended or

deposited particles. Then neutralize this solution by adding ten to twenty drops of strong ammonia and agitating. Effervescence will ensue, showing the evolution or liberation of oxygen, and if any of the suspected earths or salts be present, a flocculent cloudiness will appear, and on standing will be deposited. If the sample is entirely free from these impurities it will remain perfectly clear, while the evolution of oxygen will slowly proceed. If the sample is already decidedly acid, the addition of the phosphoric acid may be omitted, and ammonia alone used in making the test. The exact quantity of free or combined acid existing in any test-sample may be determined by neutralizing a given quantity with ammonia or carbonate of sodium, and noting the quantity of the latter required, as in case of any solution of acids.

Volumetric Strength.—Considerable vagueness exists in the minds of professional men and others as to the practical meaning of this term. It may be well to repeat that, for example, a ten-volume solution of H_2O_2 means that one pint or unit of such solution, on complete decomposition, will yield ten pints or units of gaseous oxygen, and that the percentage of strength indicated by designated volumes may be found by annexing two ciphers to the number of volumes named, and dividing this number by 475, the number of volumes of oxygen which pure or undiluted H_2O_2 will yield when entirely decomposed. Thus, a fifteen-volume solution $= \frac{1500}{4715} = 0{\cdot}03157+$, or not quite three and one sixth per cent. in strength:

To test the volumetric strength of any sample of this product the following is perhaps the simplest method of procedure; and while for certain reasons it is not technically accurate, it is closely approximate, and practically all that could be desired.

A standard solution of potassium permanganate is made by dissolving four grammes of this salt in a litre, or in the

proportion of one part in two hundred and fifty, of distilled water. In a glass or porcelain vessel of about one pint capacity put eight or ten ounces of water (distilled if convenient), and, having acidulated it with twenty or thirty drops of sulphuric acid, add, by means of a graduated pipette, exactly one cubic centimetre of the sample to be tested. Then, from a graduate accurately marked in cubic centimetres, slowly add the permanganate solution, stirring the mixture constantly with a glass rod. The purple color of the permanganate solution will for a time entirely disappear. As soon as any color remains in spite of thorough stirring, stop the pouring and note exactly how many cubic centimetres of the colored solution have been required or decolorized. This number will indicate the approximate volumetric strength of the sample. Thus, if in testing any given brand it requires twelve cubic centimetres to reach the above-described result, the sample is twelve volumes strong. In other words, it will require one cubic centimetre of H_2O_2 of one-volume strength to decolorize one cubic centimetre of the standard permanganate solution; and one cubic centimetre of a ten-volume solution of H_2O_2 will decolorize ten cubic centimetres of the standard permanganate solution.

A test of the volumetric strength of any sample of hydrogen dioxide, which is said to be much more reliable and accurate than the foregoing, is as follows:

The sample to be tested is placed in an accurately graduated test tube into the mouth of which is fitted a cork perforated to receive two small glass tubes. Into one of these perforations is to be inserted a bent glass tube which conducts evolved gas to a graduated bell glass over a pneumatic trough. A rod or tube loaded with platinum black is passed into the dioxide through the second perforation in the cork, when decomposition of the solution rapidly ensues. The escaping gas is collected in the bell, and affords an accurate

Table of Comparative Tests of Various Samples of Medicinal Hydrogen Dioxide, procured directly from the Manufacturers or their Authorized Agents.

No. of sample.	STRENGTH IN VOLS., PERMANGANATE TEST.			QUANTITY OF EARTHY SALTS PRESENT.		C. c. of standard solution of ammonia required to neutralize 1 litre.	Manufacturer's or vender's label.	Strength claimed, vols.
	Fresh sample.	After 3 weeks.	After 6 months.	Magnesia and alumina.	Other earthy salts.			
1	$8\frac{1}{3}$	$3\frac{1}{2}$	$\frac{1}{2}$	None.	Large.	30	Merck's "Medicinal," Darmstadt.	10
2	$13\frac{1}{2}$	$6\frac{1}{3}$	$1\frac{1}{2}$	Trace.	Moderate.	100	Marchand's "Medicinal," New York.	15
3	$1\frac{1}{2}$	$\frac{1}{2}$	0	Small.	Large.	150	McKesson & Robbins, New York.	10
4	15	$14\frac{2}{3}$	$11\frac{1}{2}$	None.	None.		Oakland Chemical Company, New York.	15
4, *a*.	15	13	$9\frac{1}{2}$			*a*.	Do. do. do.	15
5	13	8	$1\frac{1}{2}$	None.	Small.	$7\frac{1}{2}$	Bené's "Standard," Brooklyn, N. Y.	15
6	$8\frac{1}{2}$	8	2	Small.	Moderate.	20	Powers & Weightman, New York and Philadelphia.	No claim.
7	7	$6\frac{3}{4}$	3	None.	Moderate.	8	Mallinckrodt Chemical Company, St. Louis, Mo.	15
8	$3\frac{1}{2}$	$3\frac{1}{2}$	1	Large.	Large.	10	Perchot, New York.	10
9	$11\frac{1}{2}$	$11\frac{1}{2}$	....	None.	None.	$3\frac{1}{4}$	Larkin & Scheffer, St. Louis, Mo.	10

and reliable measure of the proportion or volume of oxygen contained in the sample.

Applying the various tests above suggested, the following table illustrates the wide variation in strength, purity, and stability of nine of the different brands now to be found in the American market. All the samples used were procured directly from the manufacturers, or from the houses whose labels they contain, and were tested immediately, so that all might have an equal showing as to freshness.

It is my observation that as the article has increased in popularity some manufacturers have apparently relaxed vigilance and allowed their product to deteriorate in quality. Samples of some of the older brands, clinically tried by me eight or ten years ago, from results observed, I can not help thinking were certainly much better than the same brands as now sold.

From the foregoing table of comparisons it will be seen that the various samples tested show marked contrasts as to acidity, freedom from earthy salts, and particularly as to keeping qualities. Thus, No. 1 of the series, which, from the high repute of its manufacturer, would be expected to lead the list, is full of impurities, decidedly acid, and rapidly deteriorates on standing. No. 2, the best-known American brand, is less tainted with earthy impurities, but is so sharply acid as to seriously interfere with its therapeutic value, and its keeping qualities are in an inverse ratio to its acidity. No. 3, although sold as "medicinal," was unquestionably a very poor sample of even the commercial article. It shows a minimum of strength, and at the same time a maximum of acidity and earthy impurities. No. 4, of which several specimens were tested, is practically free from impurities, but lacks uniformity, some samples being quiet in the bottles, while others eject the cork with considerable force and a loud report. This would indicate

that not every sample is possessed of the keeping qualities shown by those in the table. No. 5 is a fairly good specimen for immediate use, but has extremely poor keeping qualities. Nos. 6 and 7 need no comment. No. 8 falls considerably below its proprietor's claims as to strength, is tainted with earthy salts, and keeps poorly. It is charitable to assume, in spite of the proprietor's assurance that it was "medicinal," that it really was only commercial in grade.

On the other hand, No. 9, which, so far as I am aware, is the newest candidate for professional favor, is an almost ideally perfect product, and at the same time shows fifteen per cent. greater volumetric strength than is claimed for it. This would indicate that the processes of manufacture are being decidedly improved, and that there is really no further need of wasting either time, money, or patience, or of jeopardizing success in practice by using an inferior preparation.

Table of Comparative Values of Various Samples of H_2O_2, as found in this Market.

No.	VALUE PER POUND. Fresh sample.	After 3 weeks.	After 6 months.	Manufacturer's Imprint.	Strength claimed, vol.
1	$0.41	$0.17	$0.02	Merck, Darmstadt, Prussia.	10
a	unfit for med. use.				
2	0.67	0.34	0.07	Charles Marchand, New York.	15
a	0.56	0.19	0.04		
3	0.07	0.02	0.00	McKesson & Robbins, New York.	10
a	unfit for med. use.				
4	0.75	0.74	0.57	Oakland Chemical Company, New York.	15
a	0.68	0.67	0.50		
5	0.65	0.40	0.08	John Bené, Brooklyn, N. Y.	15
a	0.50	0.30	0.00		
6	0.42	0.40	0.10	Powers & Weightman, New York.	10
a	0.25	0.20	0.00		
7	0.35	0.34	0.15	Mallinckrodt Chemical Company, St. Louis.	15
a	0.25	0.24	0.10		
8	0.17	0.15	0.05	Peuchot, New York.	10
a	unfit for med. use.				
9	0.57	0.57	0.57	Larkin & Scheffer, St. Louis.	10
a	0.75	0.75	0.74		

NOTE.—The first set of figures represents the comparative commercial values, based on volumetric strength only and assuming five cents a volume as a standard of value, for purposes of comparison. The second set of figures (*a*) represents an estimated intrinsic or realizable therapeutic value, based on the qualities of comparative purity and stability.

It need not be reiterated that the real economic and therapeutic value of this agent can not be determined by the mere volumetric strength indicated on testing a fresh sample. Nor is it assumed that the above estimates are other than approximate. They are, however, based on practical tests and a somewhat extensive personal experience, and the same diligence has been used in each case to procure only perfectly fair samples of the "medicinal" article for test purposes. In each case the chemical manipulation has been repeated not less than three times before accepting results, and in nearly all the cases a portion of each sample was placed in the hands of a competent chemist for verification, the results corroborating my own provings in every instance.

[Since the foregoing tables were prepared several new candidates for professional favor have come to notice.

Under the general name of "pyrozone," McKesson & Robbins, of this city, have placed on the market three different solutions of hydrogen dioxide, as follows:

"Caustic pyrozone," an ethereal solution for which the proprietors allege a strength of 25 per cent., or nearly 120 volumes; "antiseptic pyrozone," also an ethereal solution, said to contain 5 per cent., or nearly 24 volumes; and "medicinal pyrozone," an aqueous solution which is labeled 3 per cent., or 15 volumes.

By test, the several brands respond as follows:

"Caustic pyrozone," 16 per cent., or over 76 volumes; "antiseptic pyrozone," 3·9 per cent., or nearly 19 volumes; "medicinal pyrozone," 2·1 per cent., equal to 10 volumes. In the latter the test for earthy salts shows notable traces of both sulphate and chloride of calcium.

The first two preparations would seem to be valuable acquisitions, while the last is a disappointment.

The well-known firm of manufacturing pharmacists,

Messrs. E. R. Squibb & Son, of Brooklyn, are offering to the profession, in compact form, a combination of the necessary chemicals for preparing as wanted a "definite and reliable" 10-volume solution of hydrogen dioxide, with explicit directions, so that "any physician, pharmacist, or intelligent nurse" can manage the manipulation. Each package is said to be sufficient for six pints of the finished product.

I have not yet had opportunity to test the merits of this novel departure in pharmaceutics, and therefore venture no opinion as to their value or reliability. The circular announcement assumes that no hydrogen dioxide can be made stable, which we certainly now have reason to think is a mistake.]

Thus far there has been too much careless and indiscriminate prescribing and fulsome laudation of this product, regardless of its strength or purity. The profession is beginning to discriminate, and must hold the manufacturing pharmacists to the motto: In medicine only the best is good enough.

In the face of this truism, and in the light of modern science, pharmaceutical preparations of inferior quality are dear at any price; and their employment by an intelligent physician, under any circumstances, can be excused only on the plea of actual necessity, which, in these days of electricity, rapid transit, and general progress, is rarely allowable.

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